spin-dependent scattering but with specular reflection scattering thereon. Precisely, Fig. 35A and Fig. 35B schematically show an ideal condition (this corresponds to the as-deposited condition); and Fig. 35C schematically shows the condition after annealing.

As in Fig. 35A and Fig. 35B, specular reflection scattering occurs on the both sides of the three-layered laminate structure, free layer 1/nonmagnetic spacer layer 2/pinned magnetic layer 3, of the basic unit of the spin valve GMR in the as-deposited condition (even though the interface is between metal films). However, as in Fig. 35C, in the system that readily forms solid solution in a process of annealing, interfacial diffusion occurs, or that is, the interface becomes diffusive to lower its mirror-reflectivity after annealing. As a result, it is considered that, in that system, the MR characteristics are degraded in thermal treatment.

Few reports are found relating to the specular reflection on the interface between metal films, and any positive proof of the specular reflection on that interface has not been well established as yet. However, as will be mentioned hereunder, even on the interface between metal films with small potential difference therebetween, some ideal specular reflection will occur. For example, specular reflection occurs on the interface of NiFe/CoFe in the as-deposited condition in which mixing of the two is relatively

small. However, after the system of NiFe-CoFe is annealed, interfacial diffusion occurs readily on that interface of NiFe/CoFe where the components will form solid solution, whereby the compositional steepness in the interface will be lost. As a result, it is considered that the MR ratio will lower in that system after thermal treatment.

Concretely, in a spin valve film incorporating a free layer of a laminate film of NiFe/CoFe, the specular reflection on the NiFe/CoFe interface is lost in annealing. As a result, for example, the MR ratio of 7.3 % in the as-deposited film is lowered to 5.8 % after annealing at 250°C for 4 hours. One reason for this will be because the specular reflection coefficient at the NiFe/CoFe interface would be varied in annealing, whereby the MR ratio in the film would be also varied after annealing.

In the prior art technology, the interfacial specular reflection has not been taken into consideration since the NiFe/CoFe interface is the interface between metal films and since the two, NiFe and CoFe are in nearly the same electron condition. In the as-deposited condition, the interface could be uniform with relatively low-level mixing of elements thereon, and therefore specular reflection will occur even on the metal film interface of that type. However, since the NiFe/CoFe system forms solid solution in its interface, the interface will readily diffuse and mix when annealed, whereby the

compositional steepness in the interface will be lost and the specular reflection coefficient therein will become small. As a result, the MR characteristics in the system will be degraded. In a different aspect, this means that the MR ratio in the as-deposited film is larger by the degree of specular reflection than that in the annealed film.

When the free layer is thin and MR-improving layer is disposed to the free layer, the MR-improving layer acts as the nonmagnetic high-conductivity layer in the first embodiment mentioned hereinabove. However, once the interface between the nonmagnetic high-conductivity layer and the free layer has become diffusive owing to atomic diffusion in that interface, the electron transmittance from the free layer to the nonmagnetic high-conductivity layer is lowered. In other words, even when the magnetization direction of the pinned layer is parallel to that of the free layer, the diffusive interface receives non-elastic electron scattering so that the mean free path of electrons for up-spin could not be prolonged. As a result, this induces MR ratio depression. This phenomenon is seen when the ultra-thin free layer forms solid solution with the nonmagnetic high-conductivity layer, and becomes more remarkable in thermal treatment. Accordingly, the MR ratio decreases after thermal treatment.

It is important to form a stable interface between the free layer and the nonmagnetic high-conductivity layer, which